Relative Tolerance of Peanuts to Alachlor and Metolachlor[1]

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ABSTRACT

Field studies were conducted during 1984, 1985, and 1987 to evaluate weed control and the relative tolerance of peanuts *(Arachis hypogaea)* to alachlor and metolachlor when applied at rates from 2.2 to 13.4 kg ai/ha. Both single and split preemergence, and postemergence applications were included. In 1984 and 1985, neither herbicide adversely affected yields compared to a hand-weeded control. In 1987, metolachlor at a rate of 9.0 kg/ha and alachlor at 13.4 kg/ha reduced yields. Across all years, at least a two-fold safety factor existed between the maximum registered rate and the rate necessary for peanut injury. Occurrence of injury appears to be related to rainfall. Metolachlor was slightly more mobile than alachlor in soil chromatography trials, which may be a factor in its slightly greater propensity to be injurious under certain conditions of extensive leaching and/or slow peanut emergence.

Key Words: *Panicum texanum, Desmodium tortuosum,* herbicide injury.

Alachlor and metolachlor are two herbicides commonly used in peanuts for the control of annual grasses and many species of small-seeded broadleaf weeds. They also offer suppression (a minimal degree of control) of large-seeded broadleaf species. The normal use rate of alachlor is 2.2 to 4.5 kg ai/ha and the rate for metolachlor is 2.2 to 3.4 kg ai/ha. Alachlor and metolachlor are substituted amides, and can be applied either preplant-incorporated or preemergence. The water solubility of metolachlor (530 ppm) is higher than that of alachlor (254 ppm) (7).

In recent years, extension personnel in the Southeastern United States have raised questions concerning the relative tolerance of peanuts to alachlor and metolachlor. Sporadic injury to peanuts from metolachlor has been observed in recent years, often due to the tendency of growers to apply more than the maximum registered rate. This is done in an attempt to enhance the partial control of broadleaf species, particularly Florida beggarweed *[Desmodium tortuosum* (SW) DC]. In addition, it has been alleged that metolachlor has a propensity to be injurious even when the application rate is within the registered rate. To date, no data supporting or denying this speculation have been published.

Jordan and Harvey (5) studied the tolerance of peas *(Pisum sativum* L.) to eight acid anilide herbicides, including alachlor and metolachlor. Both hydroponic and field studies indicated that peas were more sensitive to alachlor than to metolachlor. Greenhouse studies revealed that peas were most sensitive across all the substituted amide herbicides when the application was made 2 days after planting. This time of application corresponded to shoot emergence, which is considered to be the most sensitive portion of the seedling, through the surface of the treated soil. Later applications resulted in progressively less injury, indicating that the foliar portion of the developing pea was relatively tolerant once emerged. Field studies indicated injury was markedly influenced by rainfall soon after planting.

Putnam and Rice (7) evaluated the factors associated with alachlor injury on snap beans *(Phaseolus vulgaris* L.). Injury was erratic, with maximum injury associated with relatively cool dry conditions or warm moist conditions. In greenhouse studies, simulated rainfall in excess of 5 cm tended to reduce injury. This was attributed to the surface-applied alachlor having been leached below the zone through which the shoot emerged.

Substituted amides enter the tissue of germinating seedlings by both the shoot and root tissue. Armstrong *et al.* (1) demonstrated that the main site of herbicide uptake of soil-applied alachlor by yellow nutsedge *(Cyperus esculentus* L.) tubers was the portion above the tuber. Chandler *et al.* (3) studied the uptake of alachlor by wheat *(Triticum aestivum* L.) and soybean *[Glycine max* (L.) Merr.] seedlings by selectively exposing portions of the seedlings to alachlor solutions. Roots and shoots of both species readily absorbed alachlor. Absorption by wheat shoots continued over a longer period of time, resulting in greater total uptake and increased sensitivity compared to root absorption. Shoot absorption and translocation by soybeans was less than that observed with root exposure.

Differential herbicide soil sorption and mobility may be a factor in crop-weed response. Alachlor and metolachlor soil sorption has been correlated to the relative abundance of organic matter and clay (8). Generally, alachlor is subject to slightly more sorption than metolachlor. Conversely, metolachlor is more prone to leaching, due partially to the greater water solubility of metolachlor, [water solubility of metolachlor = 530 ppm, alachlor = 242 ppm (2)] (6).

The purpose of this study was to evaluate the relative crop safety of alachlor and metolachlor when applied at 2.2, 4.5, 9.0, and 13.4 kg ai/ha. In addition, the mobility of these herbicides within the pertinent soil type was evaluated.

Materials and Methods

Field studies. Field studies were conducted during 1984, 1985, and 1987 at the Wiregrass Experiment Station located near Headland, Alabama on a Dothan loamy soil (Plinthic paleudults). Florunner peanuts were planted (128 kg/ha) in a well prepared, flat seedbed using conventional equipment. Seeding depth was 5 cm, and row spacing was 91 cm. Planting dates were May 19, 1984, May 13, 1985, and May 13, 1987. The experimental area was infested with natural

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populations of Texas panicum (*Panicum texanum* Buckl) and Florida beggarweed. Fertility, cultural, and other pest management practices were conducted as recommended by the Alabama Cooperative Extension Service.

Herbicide treatment consisted of alachlor and metolachlor applied preemergence at 2.2, 4.5, 9.0, and 13.4 kg/ha, or, with the three higher rates, as a split application. That is, one-half of the prescribed amount was applied preemergence and the second half was applied early postemergence. This latter application approximated the 'cracking time' application timing observed by growers (see Table 5 for time of applications). A randomized complete block experimental design with four replications was used. Nontreated weedy and hand-hoed weed-free controls were also included. Individual plot size was 3.7 m (4 rows spaced 91 cm apart) by 6.1 m long. The right two rows of all plots were maintained weed-free by weekly hand hoeings and cultivations, preventing weed interference from confounding the evaluation of herbicide injury on peanut yield.

Data collected included visual estimates of weed control on a scale of 0% (no control) to 100% (complete control) taken approximately 2 weeks before harvest, crop injury (taken 3 weeks after the last application), peanut yields, and peanut grades (percent sound mature kernels). Peanut yield and grade were taken only from the weed-free portion of the plots. Estimated weed control was on the basis of weed density and vigor. Data were subjected to analysis of variance. Treatment means, where applicable, were compared with Fisher's Least Significant Difference (LSD) test at the 5% level of probability.

Soil mobility. The mobility of alachlor and metolachlor in the Dothan loamy sand soil was evaluated by thin-layer soil chromatography as described by Helling (4). The sand, silt and clay content for this soil was 83, 7 and 10%, respectively. Percent organic matter, pH, and cation exchange capacity were 1.2%, 6.4, and 5.5 milliequivalents/100 g, respectively. The soil chromatograph consisted of a 3-mm thick layer of soil (40 mesh screen) deposited on a 12 by 60 cm glass plate. Solutions of ^{14}C- labeled alachlor and metolachlor were spotted near the bottom of the plate and developed in water for a distance of approximately 10 cm. Distance between the origin and the wetting front was divided into 10 1-cm increments. Each increment was removed by scraping and the amount of radioactivity determined by liquid scintillation spectrometry, Scintillation Counter Model 3800, Beckman Instruments, 2500 Harbor Blvd., Box 3100, Fullerton, CA 92634. Procedures were repeated four times with each herbicide. Distribution of alachlor and metolachlor was compared with the chi-square goodness of fit test.

Results and Discussion

Field studies. Statistical analysis revealed that weed control, crop inuury and peanut yield differed between the years, thus data for each year is presented separately. In 1984, Texas panicum control (Table 1) was influenced by herbicide and application rate. Good to excellent control (>80%) required 13.4 kg/ha of alachlor or 9.0 kg/ha of metolachlor. Texas panicum presure was light and variable in 1985, thus all treatments provided good to excellent control. None of the treatment variables were significant and no differences between individual treatments were evident. Herbicide rate was the only significant variable in 1987. Application method had no effect on Texas panicum control in any year. Only in one year, 1984, was a difference between the herbicides detected. In this case metolachlor provided superior control (80% control, as averaged across all treatments, compared to 64% control for alachlor).

Florida beggarweed control was influenced by all treatment variables in 1984 and 1985; however, only rate was significant in 1987 (Table 2). Metolachlor provided superior control compared to alachlor (overall average of 62% compared to 32%, respectively, in 1984, and 95 to 79%, respectively in 1985). In 1984, both her-

Table 1. Texas panicum control as influenced by rate of alachlor and metolachlor applied as either a single preemergence or as a split preemergence and postemergence application.

Herbicide rate	Alachlor Single	Alachlor Split	$\bar{x}$	Metolachlor Single	Metolachlor Split	$\bar{x}$
(kg/ha)	(%)					
			1984			
2.2	31	---	31	51	---	51
4.5	69	63	66	86	62	74
9.0	68	74	71	99	93	96
13.4	87	88	87	99	99	99
Untreated-weedy[1]	(0)					
			1985			
2.2	100	---	100	100	---	100
4.5	100	98	99	100	100	100
9.0	100	100	100	100	100	100
13.4	100	98	99	100	100	100
Untreated-weedy[1]	(0)					
			1987			
2.2	46	---	46	64	---	64
4.5	81	78	79	85	83	84
9.0	70	91	81	85	97	91
13.4	84	93	88	84	96	98
Untreated-weedy[1]	(0)					

Analysis of variance:

Source of variation[2]	Probability 1984	1985	1987
Herbicide	0.007	NS	NS
Single or split application	NS	NS	NS
Rate	0.001	NS	0.001

[1]A single untreated check was used in each year.

[2]None of the interactions with the variables tested were significant in any year. Fisher's protected $LSD_{0.05}$ value to compare the means of the two herbicides within a common rate = 11 (1984 data).

Table 2. Florida beggarweed control as influenced by rate of alachlor and metolachlor applied as either a single preemergence or as a split preemergence and postemergence application.

Herbicide rate	Alachlor Single	Alachlor Split	$\bar{x}$	Metolachlor Single	Metolachlor Split	$\bar{x}$
kg/ha	(%)					
			1984			
2.2	17	---	17	33	---	33
4.5	24	11	18	78	15	47
9.0	62	15	39	98	54	76
13.4	87	27	57	98	83	91
Untreated-weedy[1]	(0)					
			1985			
2.2	60	---	60	81	---	81
4.5	71	84	78	74	86	80
9.0	79	93	86	95	100	97
13.4	90	95	93	100	100	100
Untreated-weedy[1]	(0)					
			1987			
2.2	59	---	59	85	---	85
4.5	90	91	91	91	84	87
9.0	92	91	92	91	94	92
13.4	95	93	94	94	95	94
Untreated-weedy[1]	(0)					

Analysis of variance:

Source of variation[2]	Probability 1984	1985	1987
Herbicide	0.001	0.001	NS
Single or split application	0.001	0.008	NS
Rate	0.001	0.001	0.001

[1]A single untreated check was used in each year.

[2]Significant 2-way interactions were as follows: application method by rate (P=0.001 in 1984 and P=0.032 in 1985), and herbicide by rate in 1987 (P=0.045). Fisher's protected $LSD_{0.05}$ value to compare the means of the two herbicides within a common rate = 8 (1984 data), and 6 (1985 data).

bicides provided better control when applied as a single preemergence application as compared to a split application (58% versus 18%, respectively, for alachlor; and 91% versus 51% for metolachlor). This trend was reversed in 1985 with the split application slightly more effective. This performance can be in part attributed to rainfall pattern. In 1984, rain (1.93 cm) occurred within 5 days after the preemergence application (Table 5). Conversely in 1985, rain was not received until 19 days after the preemergence application, and 7 days after the post-emergence application. As expected, a rate response was evident in all years.

Crop response. In 1984, no visual injury was evident (Table 3). Neither the main effects of herbicide, method of application, nor the interactions were significant. However, examination of individual treatments revealed a trend for metolachlor at the 13.4 kg/ha rate to result in a lower yield than the untreated control (Table 4). This was more evident with the split application.

Table 3. Percent visual crop injury with various rates of alachlor and metolachlor applied as either a single preemergence or as a split preemergence and postemergence application.

Herbicide rate	Alachlor Single	Alachlor Split	Alachlor $\bar{X}$	Metolachlor Single	Metolachlor Split	Metolachlor $\bar{X}$
kg/ha	(%)					
			1984			
2.2	0	---	0	0	---	0
4.5	0	0	0	0	0	0
9.0	0	0	0	0	0	0
13.4	0	0	0	0	0	0
Untreated-weedy[1]	(0)					
			1985			
2.2	0	---	0	9	---	9
4.5	1	7	4	5	11	8
9.0	3	15	9	5	11	8
13.4	6	10	8	11	15	13
Untreated-weedy[1]	(0)					
			1987			
2.2	0	---	0	0	---	0
4.5	0	0	0	8	1	5
9.0	1	3	2	36	14	25
13.4	6	1	4	38	24	26
Untreated-weedy[1]	(0)					

Analysis of variance:

Source of variation[2]	Probability 1984	Probability 1985	Probability 1987
Herbicide	NS	NS	0.001
Single or split application	NS	0.004	0.001
Rate	NS	NS	0.001

[1]A single untreated check was used in each year.

[2]Interaction of method of application by rate was significant in 1985 (P=0.005); in 1987, all 2-way variable interactions were significant (P=0.001). Fisher's protected $LSD_{0.05}$ value to compare the means of the two herbicides within a common rate = 6 (1987 data).

In 1985, crop response was significantly influenced by herbicide rate; however, no difference between the two herbicides was detected (Tables 3 and 4). Increasing the rate of a single application of alachlor or metolachlor resulted in a trend for enhanced visual injury and reduced yields. Across all other variables, the split application resulted in greater visual inuury, but no yield reduction. In contrast to this trend, which was evident within the means, increasing rates of metolachlor with split applications resulted in improved yields. Generally, the better performing treatments had greater yields than the hand weeded check. This reflects injury that is inadvertently inflicted upon the crop by the pulling of weeds.

Table 4. Peanut yield (kg/ha) (weeds removed) as influenced by various rates of alachlor and metolachlor applied as either a single preemergence or as a split preemergence and postemergence application.

Herbicide rate	Alachlor Single	Alachlor Split	Alachlor $\bar{X}$	Metolachlor Single	Metolachlor Split	Metolachlor $\bar{X}$
kg/ha	(%)					
			1984			
2.2	4070	----	4070	4330	----	4330
4.5	4140	4040	4090	3940	3920	3930
9.0	4330	4050	4190	4150	3920	4040
13.4	4200	3940	4070	3880	3210	3545
Untreated-weedy[1]	(4040)					
			1985			
2.2	4960	----	4960	4650	----	4650
4.5	4400	4770	4585	4425	4165	4295
9.0	4300	4020	4160	4130	4300	4215
13.4	4770	4530	4650	4250	4650	4450
Untreated-weedy[1]	(4050)					
			1987			
2.2	4220	----	4220	3830	----	3830
4.5	4430	4590	4510	4090	4215	4150
9.0	4000	4400	4220	3400	3280	3340
13.4	3390	3090	3240	2440	3165	2800
Untreated-weedy[1]	(3890)					

Analysis of variance:

Source of variation[2]	Probability 1984	Probability 1985	Probability 1987
Herbicide	NS	NS	0.001
Single or split application	NS	NS	0.003
Rate	NS	0.021	0.001

[1]A single untreated check was used in each year.

[2]Interaction of herbicide by rate and method by rate were significant in 1987 (P=0.033 and P=0.014, respectively). Fisher's protected $LSD_{0.05}$ value to compare the means of the two herbicides within a common rate = 252 (1987 data).

All main effects for injury and yield were significant in 1987. All treatments in which metolachlor was applied at 9.0 kg/ha or higher yielded less than the check. Likewise, alachlor applied at 13.4 kg/ha decreased yields, especially with the split application. Peanut grade was not affected by alachlor or metolachlor in any treatment or year (data not shown).

In all three years, a relationship between injury and rainfall was evident (Table 5). In this respect, our data with peanuts is similar to that of Jordan and Harvey (5) Putnam and Rice (7) both working with other legume crops. In 1985, a year in which no injury was evident across all treatment variables, no rainfall was received until six days after the preemergence application (0.05 cm), and four days after the postemergence application (0.33 cm). Injury was most evident in 1987, when following preemergence applications, rain fell for six consecutive days, totalling 7.06 cm. Within one day after the postemergence applications, 0.56 cm of rain fell. In 1984, an intermediate year in terms of injury, no rain fell for five days after the preemergence application (1.93 cm). Between the second and the fifth day after the postemergence treatments were applied, rain fell daily, totalling 3.89 cm.

Soil mobility studies revealed that for both alachlor and metolachlor, the majority of the herbicides were not leached beyond the second or third increment from the origin (Table 6). Yet the distribution between alachlor and metolachlor was significantly different. The greatest amount of metolachlor was recovered in the third increment, but with alachlor, the greatest amount was in the second increment. Thus, metolachlor was slightly more mobile than alachlor. This is in agreement with other research (6). Under conditions conducive to leaching (i.e. rainfall subsequent to application) metolachlor would probably have a slightly greater propensity to reach the developing seedling.

As previously mentioned, the registered use rate for alachlor in the soil in which this study was conducted is 2.2 to 4.5 kg/ha, and 2.2 to 3.4 kg/ha for metolachlor. In none of the 3 years in which the study was conducted would the maximum registered amount of either herbicide have resulted in unacceptable injury and/or yield loss. For both herbicides there appears to exist at least a two-fold safety factor between the maximum registered rate and the rate necessary to result in injury. Our data does not support the contention that metolachlor has a greater propensity to result in inuury than alachlor, provided applications of the herbicides are within the registered rates. Under circumstances such as accidently applying excessive rates, and/or heavy rainfall following herbicide application, crop injury may be more likely to occur with metolachlor than with alachlor.

Table 5. Rainfall distribution subsequent to planting and herbicide applications.

Days after planting[1]	Rainfall 1984	Rainfall 1985	Rainfall 1987
	(cm)		
0	----	---- (pre.)$^{5/13}$	---- (pre.)$^{5/13}$
1	---- (pre.)$^{5/10}$	----	0.10
2	----	----	1.27
3	----	----	0.71
4	----	----	1.04
5	----	----	1.33
6	1.93	0.05	2.61
7	----	----	----
8	----	----	---- (post.)$^{5/20}$
9	----	0.02	0.56
10	----	----	----
11	----	----	----
12	----	---- (post.)$^{5/25}$	----
13	0.05	----	----
14	---- (post.)$^{5/23}$	----	----
15	----	----	----
16	0.10	0.33	----
17	1.40	0.10	----
18	0.30	----	----
19	0.03	2.79	----
20	2.06	0.20	----
21	----	----	----
22	----	----	----

[1]Planting dates for the three years were May 9, 1984, and May 13 in both 1985 and 1987.

Table 6. Distribution of alachlor and metolachlor in Dothan sandy loan soil as determined by thin-layer soil chromatograph[a].

Increment no.	Alachlor	Metolachlor
	(% of total radioactivity recovered[b])	
1	12	9
2	45	39
3	35	44
4	7	7
5	1	1
6	0	0
7	0	0
8	0	0
9	0	0
10	0	0

[a]Concentrations of spotting solutions were 0.5 ppm. Wetting front was allowed to progress approximately 10 cm, thus each increment was approximately 1 cm.

[b]Distribution of alachlor and metolachlor was significantly different (P=0.004) according to a chi-square comparison.

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